Monitoring Mixed Waste Treatment Processes and Effluents

Continuous Emission Monitors for Feedback and Compliance

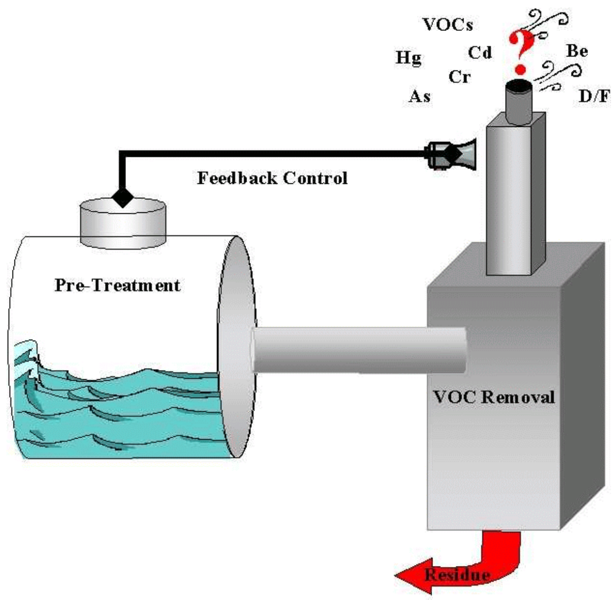
CEMs: what, why and where?

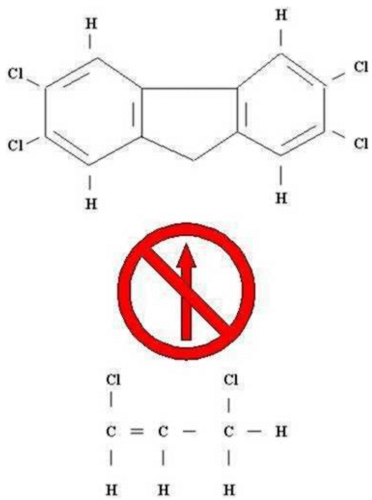
DOE must employ continuous emission monitors (CEMs) in order to ensure proper operation of its mixed waste treatment facilities. CEMs enhance regulator and stakeholder confidence that emissions will remain within limits, hence reducing waste feed characterization and off-line testing requirements. Operating limits based on trial runs cannot ensure compliance during routine operation. CEMs are needed for mercury, multiple metals (MM), dioxins and furans (D/F), and particulate matter (PM) in order to provide both continuous emission records and real-time process control.

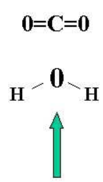
Treatment is needed for low-level and high-level radioactive waste, mixed transuranic waste, and nuclear materials as well as mixed waste. Treatment systems such as waste melters, incinerators, and plasma systems have been explored. Future processes may include steam reforming, thermal desorption, and chemical oxidation; developing CEMs for alternate treatments is a natural extension of current CEM development.

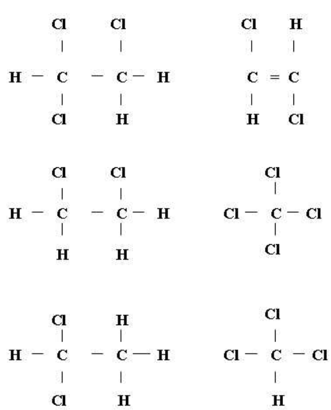
Particulate matter

High efficiency particulate air (HEPA) filters present a primary challenge to PM CEM development. PM levels down-stream of HEPA filters are orders of magnitude lower than both the emission limit and the levels of detection (LOD) for current PM CEMs and possibly below the LOD for the EPA Reference Method as well. A joint EPA/DOE National Technical Workgroup is addressing the resulting challenges.









Mercury

Mercury (Hg) is present in many DOE waste streams. Few treatment facilities can suppress Hg emissions, so facility designs and permits assume that all Hg in the feed is emitted. The maximum waste feed concentration would need to be less than 10 ppm to comply with the current limit; sampling and analyzing to that level is costly and would greatly increase the potential for worker radiation exposure. Savings in waste characterization could easily offset the cost of Hg CEMs. DOE is involved in several collaborative efforts aimed at developing and gaining regulatory acceptance for Hg CEMs.

Multiple metals

Maximum Achievable Control Technology (MACT) Rule metals include mercury, cadmium, lead, arsenic, beryllium, and chromium. Except for mercury, DOE facilities readily meet MM emission limits, because they are present mostly in the particulate phase and DOE facilities have extensive PM control for radionuclides. The incentive to develop and deploy MM CEMs comes from stakeholder interests in assuring that hazardous metal emissions are monitored and communicated on a continuous basis, as well as from a desire to minimize waste feed analysis costs.

Dioxins and furans

The primary source of D/F is formation during combustion or thermal treatment, through mechanisms not yet totally understood. Regulatory levels are extremely low, not achievable by any "real-time" monitor, making the study of D/F formation laborious and costly. A coordinated industry-EPA-university program is developing a D/F CEM to aid this study. "Near real-time" data available within minutes rather than weeks will allow researchers to generate data much more efficiently over a much wider set of experimental conditions.

In Situ Detection of Surface Contamination to Free Release Goals

The Surface and Airborne Beryllium Monitor

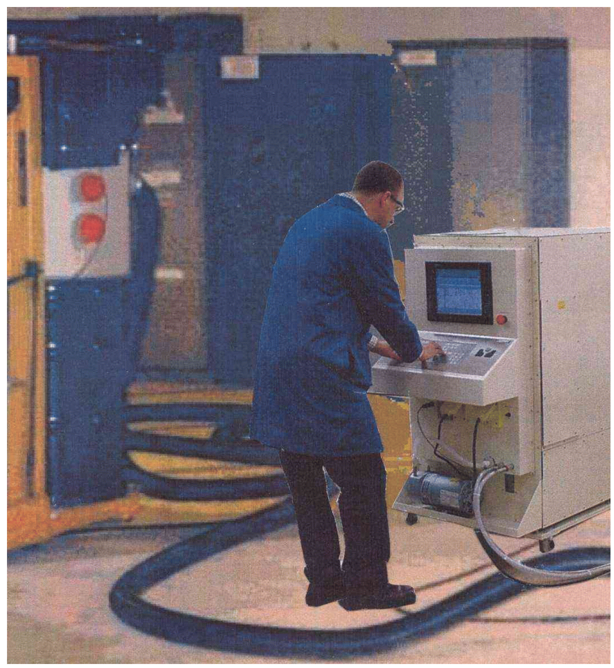
D&D safety challenges

The decontamination and decommissioning (D&D) of excess DOE facilities involves potentially great hazards to workers and others. The varied nature of facilities undergoing D&D presents a wide range of characterization and resulting technology development challenges. One challenge at the Rocky Flats Environmental Technology Site (RFETS) and elsewhere arises during characterization and D&D of property and equipment contaminated with beryllium (Be). RFETS is concerned about potential exposure to airborne beryllium re-suspended from surfaces and the potential liability associated with property release. Epidemiologists believe that no safe exposure level exists for airborne beryllium and that dermal exposure may result in sensitization.

A Be surface and air monitor

DOE will benefit greatly from having a nearly instantaneous, continuous monitor for both surface and airborne beryllium contamination. Such a monitor will improve worker safety by providing an alarm for airborne beryllium. As a surface monitor, it will allow for more effective free release of property and aid in identifying contaminated areas prior to potential worker exposure. These safeguards will increase worker efficiency and accelerate site closure.

Such a monitor is being developed by private industry in a four-way collaboration with DDFA, INDP, and CMST-CP. To initiate the process INDP issued a Request For Proposal through DOE's National Energy Technology Laboratory (NETL). CMST-CP personnel canvassed the DOE



complex, including RFETS, to determine technical specifications. A technical evaluation committee was formed to evaluate the proposals received; this committee was comprised of INDP and CMST-CP personnel with advisors from RFETS, Los Alamos National Laboratory, and Lovelace Respiratory Research Institute. The company submitting the winning proposal is currently funded to develop the real-time Beryllium Surface and Air Monitor. Review comments on its draft engineering design were provided by RFETS end-user (D&D and Environmental Safety and Health), INDP, and CMST-CP personnel.

Experience and teamwork

The winning solution is based on extensive experience with laser induced breakdown spectroscopy (LIBS) instrumentation. An important part of the instrument design is proper consideration of aerosol behavior and properties, including size distribution. Lovelace Respiratory Research Institute will provide the world class aerosol science capabilities needed to ensure that the end result is a robust instrument ready to meet the required performance certifications.

Demonstration and delivery

A critical development step is an on-site demonstration including federal and state regulators at a RFETS D&D facility. Because of the critical importance of regulatory acceptance to the deployment of innovative technologies, every effort is being undertaken to involve regulatory bodies early in the development process to help them acquire confidence in the instrument. Two prototype monitors have been fabricated and tested; these are being demonstrated and deployed at Rocky Flats and Paducah (May 2002). Additional monitors will be fabricated according to market demand.

VIP

Long-Term Monitoring of Remedial Measures

Remedy Performance Verification

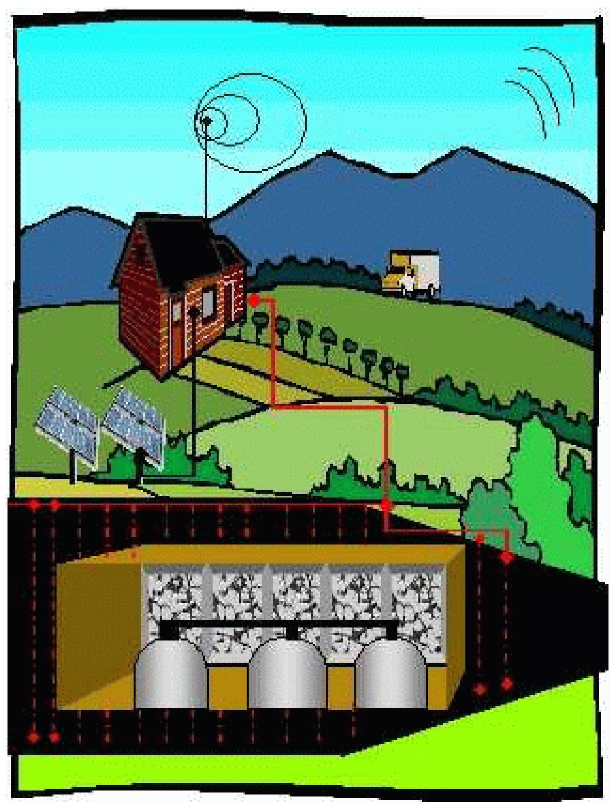
Remedial measures

All major DOE sites will require long-term monitoring of remedial measures including natural processes, containment, and stabilization. SCFA has identified a three-pronged approach: in situ sensors for VOCs, heavy metals, and radionuclides in groundwater; advanced geophysical tools for monitoring vadose zone contaminant fluxes and geostatistical techniques to validate them; and aerial monitoring to detect contaminant releases in large, difficult to access areas.

Containment and stabilization

Since containment is often a preferred remedy, DOE-EM has sponsored several technology development projects for verification and monitoring of caps, covers, and barriers used with buried waste. These include remote sensing systems, subsurface barrier validation using the SEAtrace™ system, barrier monitors using ERT, the advanced tensiometer, and a remote real-time radiation tracking system for surface soils. The latter, although designed for day-by-day direction of remediation operations, includes remote reporting and data acquisition capabilities as well as analysis software potentially useful in long-term monitoring of remote areas.

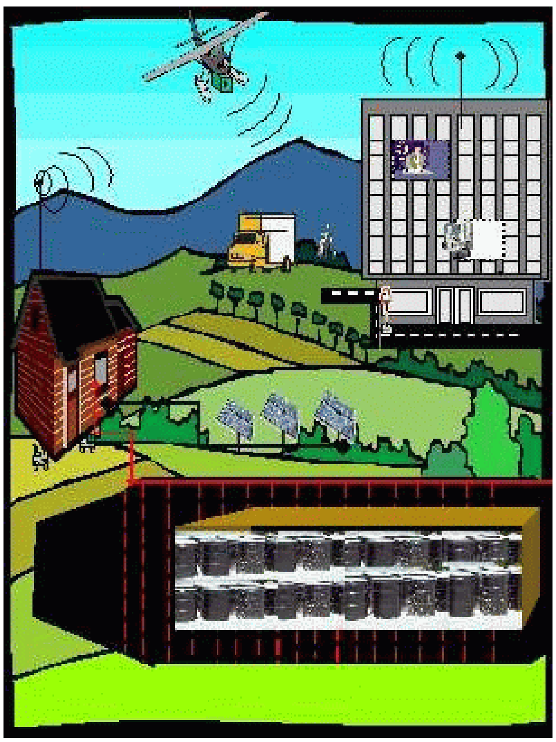
Current and future technology development related to long-term monitoring should include autonomous in situ landfill cap, cover, and barrier sensors which are self-maintaining, self-calibrating, and self-validating. Parallel evolution in data transmission, recording, and integration along with advances in regulatory strategies are needed to enable DOE to benefit optimally from these advances.



Monitored natural attenuation

An important future focus will be on post-closure monitoring and natural remediation processes such as monitored natural attenuation and bioremediation. Monitoring will help determine the efficacy of these natural processes to aid in identifying measures for their enhancement.

Regulatory buy-in and EMSP research



Regulatory acceptance of natural attenuation and/or bioremediation for organic contaminants in the subsurface will require demonstrations that actual decontamination is occurring, rather than mere dilution of the contaminant by diffusion into a larger volume. Several EMSP projects are exploring potential techniques. One involves using ratios of carbon isotopes to determine whether or not biodegradation is occurring; other isotopic ratios have been used to study the exchange between aquifer layers. Another EMSP project explores the use of precise isotopic ratio measurements of chlorine and carbon to evaluate in situ bioremediation of chlorinated organic solvents. Other projects involve genetic engineering approaches to developing microorganisms for bioremediation of chlorinated organics in mixed wastes with high radiation levels as well as of a variety of other contaminants found at DOE sites.

Advanced Monitoring Systems Initiative

The Advanced Monitoring Systems Initiative (AMSI) has been created to establish a vertically integrated development and testing operation at the Nevada Test Site capable of taking promising new sensor and sensor system concepts from the research bench to field application demonstrations swiftly, keeping up with the ever-accelerating pace of innovation in micro- and nanosystems.

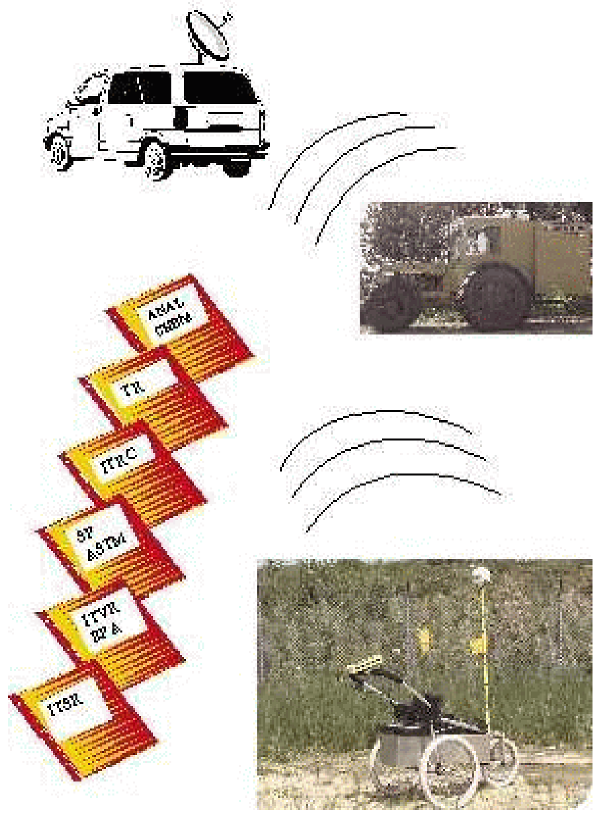
VIP

Improved Methods and Strategies for Managing and Interpreting Data

Regulatory and Stakeholder Involvement Critical

Novel technology yields novel data

Previous projects have yielded significant advances in the effective use of real-time data in characterization and remediation. These include Expedited Site Characterization (ESC), Geophysical and Hydrogeological Data Fusion, Adaptive Sampling and Analysis Programs (ASAPs), PLUME - Groundwater Modeling Software, and RSS Software for Soil Excavation Control. These provided ways of using data generated on-site by multiple sources in making reliable, accurate, timely, and defensible decisions. Three conceptual components are involved: data collection (both hardware and software); improved decision strategies and concepts (data fusion and other decision support tools); and methods to ensure acceptability of the resulting decisions.



Data collection systems

Previous advances include transmitting mobile sensor data along with global positioning system (GPS) location data by radio to a central on-site facility. This enables real-time mapping of radiation levels at Fernald and Oak Ridge in support of soil excavation and remediation decisions. The RSS Software provides the real-time mapping and decision support needed.

Decision models

Advances include using of Bayesian geostatistical analysis to combine prior information, such as historical records, modeling results, and institutional memory, with sampling data to update estimates of contamination likelihood or concentrations. ASAPs is a peer-reviewed procedure for performing such analyses.

$$f(x|a) = \frac{f(x)f(a|x)}{\int f(\xi)f(a|\xi)\,d\xi}$$

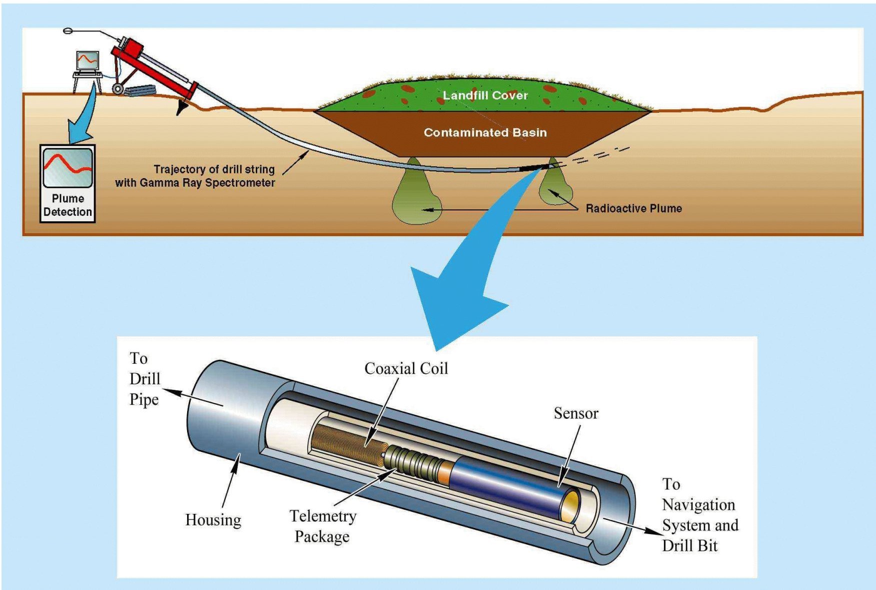
Regulatory acceptance

Peer review has aided the acceptance both ASAPs and ESC, the topic of an ASTM Standard Practice. Also, the goals of the EPA ETV Program and the Interstate Technology Regulatory Council are to foster and accelerate the regulatory acceptance of innovative technologies.

Future development

Commercial entities are developing networks to gather real-time data from in situ sensors; there is considerable interest in government and academic research communities as well. DOE-EM should promote the exchange of information about new developments, the state of the technology, and DOE, regulator, and stakeholder requirements through workshops, collaborative working groups, and other means. Particular concerns for long-term monitoring include sensor self-calibration and self-testing, data transmission and recording integrity comparable to current practice, and automated data screening algorithms.

Parallel development of design and decision strategies is needed, involving regulatory agencies, regulated parties, and ultimately stakeholder. One path forward is to continue presenting proposed innovative methodologies for peer review in professional publications as well as forums such as ASTM. Another is continued DOE-EM participation in inter-agency task groups; such participation both brings DOE expertise to the evolution of regulatory thinking and ensures representation of DOE concerns in that evolution. In addition, DOE-EM should collaborate with other government agencies in disseminating information on optimal monitoring and modeling designs, technologies, and software.



TechID 8: Environmental Measurement While Drilling